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Impact Evaluation of Procedurally Content Generated Against Immersion Games Using ANOVA

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***Abstract*— This article explains the study of the impact of procedurally content generated on immersion games and has the quality of experience playing games. Therefore, experimental studies have been conducted in which players play two different versions of the game, procedurally generated content and human design. Using the questionnaire game immersion to measure the quality of the playing experience and will be compared into two groups. While there is a difference in total immersive, one-way ANOVA statistical analysis is suggested to analyze immersive total results. However, the statistical results of one-way ANOVA are not inclusive. For this reason, one-way ANOVA will be compared with two-way ANOVA, so that it shows conclusive results based on the results of the analysis, P-Value value from the PCG game level and human design one-way ANOVA. From the participant's human design and 0.38 from PCG participants.**

Keywords*— *immersion, games, ANOVA, PCG

I. INTRODUCTION

A review of a game can be seen from several aspects, one of which is from seeing the player's experience in playing games. This experience is called *immersion*. *Immersion* has an important role in the game world to measure the level of enjoyment of the game and makes the results of good gaming experience [1][2]. However, there are several components in measuring the level of play of a game that is *Procedurally Content Generated* (PCG) [3].

PCG can be used for a variety of functions, including providing variation, reducing development time and development costs, saving space in transmission or on disks, increasing human creativity and enabling adaptation in games [4]. PCG is considered difficult because it not only causes extensive computing but also requires the ability to calculate the technical value of the resulting instance [5]. The problem in developing digital games is the lack of the ability of the game to keep players interested in playing the game, so many games do not last long [6], [7]. For analysis, *immersion* players use the *Analysis of Variance* (ANOVA) method, a statistical method that can process data by describing the total variance of data into components that measure various sources of variance.

The Approach to *Analysis of Variance* (ANOVA) orthogonal polynomial models can be performed on designs with quantitative factors and the distance between levels of the same factor. This approach is done if you want to determine the level of factors of each factor that optimizes the observed response. To determine the best model [8]. in the approach *Analysis of Variance of the largest calculated* (ANOVA)for the orthogonal polynomial model is to see the value among the models. In a previous study conducted by Andy examined the impact of *Generated Content Procedure* on *immersive games* using the one-way ANOVA method, which focuses on evaluating players from the game content, the core of this session is the *game environment* that is felt by players. In evaluating the *Content Generated Procedure* (PCG) previous research compared the *Content Generated Procedure* with *Human Design*, then the players filled out a questionnaire with the IEQ *(Immersive Experience Questionnaire)* method to be processed using the one-way ANOVA method. However, the results of his research conclusions are outlining a study that compares *immersive* the perceived resulting from playing two versions of the game, one in which the level of the game is designed by the *human design* and the level of game *content generated*. While the results are statistically inconclusive, there is sufficient evidence to show that procedurally generated content is not successful in involving players and levels designed by humans. Further research will develop various approaches to close this gap in *immersive* perceived by providing a more sophisticated approach to producing content [9].

This study will compare the previous research method [9], which shows the results of statistics using one-way ANOVA on *immersion games* that are not conclusive or accurate, with a two-way ANOVA method to analyze data *immersion game* obtained from players *mobile legend game* with questionnaire data collection using IEQ *(Immersive Experience Questionnaire)*. So that it is expected that this study can show results from more conclusive statistics.

II. RESEARCH METHODOLOGY

A. Immersion in Game

Immersive ideas and interesting experiences are not new concepts and there are several other concepts that have links with dyeing that have been considered. The three main ideas used extensively to describe interesting experiences are flow, cognitive absorption, and presence. However, we argue here that immersion is clearly different from established and better concepts. An understanding of immersion will be very

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important in understanding the relationship between people and videogames. Immersion is not well defined; despite the use of terms that are widespread in the industry *game* and media *game*. Although it has been identified that it does occur when playing *games*[3], specific attributes that contribute to such conditions are still in the process being studied. In the work [10], *immersive* has a specific definition, related to other ideas; flow, cognitive absorption, and presence. Presence describes physiological conditions in a virtual environment. Identify that this definition does not cover all aspects. games and maybe not an accurate measure of the success and quality of a game. Interesting from overlapping and universally applicable parts among these ideas [10]. continue to set immersive as a potential measure of video game quality.

B. Flow

Immersive means distorting time and providing challenges that involve a person in a task. Immersive is clearly a precursor to flow because feeling so involved is another practical thing, defining everyday life from immersive. However, flow is a type of experience, especially optimal and extreme experience. Immersion is not always extreme. Brown and Cairns [1][2]. strongly show that immersive is a multilevel experience that develops through degrees of involvement. A person can be very involved in playing a videogame but still has to be aware of other things. Like leaving the game immediately to take the bus or go to college. Players remain immersive in some games, but they are not immersive or dissolve by putting aside playing games when there are other activities because it does not flow in that person.

C. Cognitive Absorption

Immersive(CA) as a state of deep involvement with software. Similar to flow, CA is shown through the following five dimensions: temporal dissociation, the focus of attention, increased pleasure, control, and curiosity. The main objective of CA Research is to enrich the understanding of reactions to Information technology [11]. The survey of 288 students, Agarwal and Karahana suggested that people's responses to information technology were influenced by two important beliefs such as perceptions of usability and ease felt by users.

The obvious difference between immersive CAs is CA is an attitude towards general information technology, while immersive is an actual experience specifically for playing videogames. Where Immersive discusses factors similar to CA, it is a specific example of play and not like CA that is not related to motivation to play like curiosity. So, while it is possible for someone to be, in general, very absorbable in using Information Technology, in particular, is absorbed in playing games.

D. Procedurally Content Generated

Evolutionary Procedural Content Generation (EvoPCG) is PCG based on a search where the search algorithm uses an evolutionary basis. In general, searches are based on PCG[6]. To provide an opportunity to explore a large search space and find unique solutions, it might not be generalized using a more traditional approach. PCG can be classified into two parts, namely *online* PCG and PGC *offline*[12] [13]. PCG *Online* has the potential to influence factors such as *replayability* games and promote the emergence of new game dynamics but works [14] specifically discuss PCG offline. PCG Offline can provide facilities in the game development process and involves systems that help game developers in their design process or through game asset creation [15],

E. ANOVA

Two-way classification testing without interaction is a hypothesis testing of three or more average differences with two factors influences and interactions between the two factors are omitted [16]. In this research, we use the formula two-way Anova and you can see in table 1. in this table explained step of use two-way Anova.

TABLE I FORMULAS FOR TWO-WAY ANOVA [17]

Source of Variance	Amount of squares	Free degrees	Squared	f_0
Average Line	JKB	$b-1$	$S_1^2 = \frac{JKB}{db}$	$f_1 = \frac{S_1^2}{S_3^2}$
Average column	JKK	$k-1$	$S_2^2 = \frac{JKK}{db}$	
Error	JKE	$(k-1)$ $(b-1)$	$S_3^2 = \frac{JKE}{db}$	$f_2 = \frac{S_2^2}{S_3^2}$
Total	JKT	$kb-1$		

The assumptions referred to are model additives, normality, variance homogeneity and the independent nature of the error, should be examined before ANOVA is taken, namely the Assumption of Normality or NormalityOS is *Kolmogorov-Smirnov* test (KS test) is a non-parametric statistical test. The tested for a one-sample test which allows a comparison frequency distribution with several well-known distributions, such as a normal distribution *Gaussian*. The advantages of the *Kolmogorov-Smirnov test* (KS)are:

- KS does not require grouped data.
- KS can be for small samples.
- KS is more flexible.

The assumption of normality can be done by looking at the Significant *Kolmogorov-Smirnov value* for the real level of α [8].

III. THE RESULTS AND DISCUSSION

In this study, the *immersion player* aims to be evaluated in order to measure the quality version of the game. Specifically examined based *immersive* on the players in the questionnaire [10]. The total participants who took part in the questionnaire amounted to 300 people. After filling in a number of questions, data is available for 228 players choosing classic or ranked (Human Design) mode games and 72 players choosing Brawl (PCG) game mode. Shows a comparison of the ages of the two-game mode groups that have participated (Figure 1).

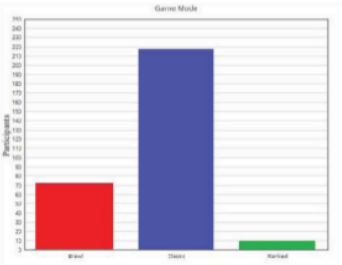

Fig. 1. Compare game mode from participants

Total Immersion Analysis

]Total *Immersion* according to [18], where respondents fill in questions based on the *Immersive Experience Questionnaire* (IEQ). To facilitate this, the data captured using IEQ has been adjusted so that all questions get a good score. The two groups on the age chart showed a mixture of various ages who had participated in filling out the questionnaire, but the majority of the age data from the two groups were aimed at ages 18 to 23 years. Shows the results of a comparison of ages in both groups (Figure 2).

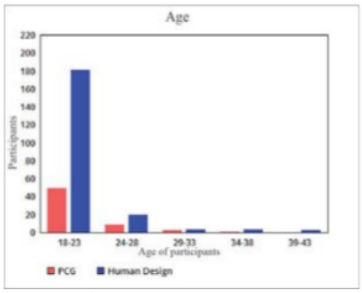

Fig. 2. Compare ages from two group

Both groups of male and female genitalia have a significant comparison because in male genitalia there is a greater number of game players than female sex based on the graph and from both gender groups, *human design* (*Classic* or *Ranked*) dominates more than PCG (*Brawl)*. Shows the results of a comparison of gender from both groups (Figure 3).

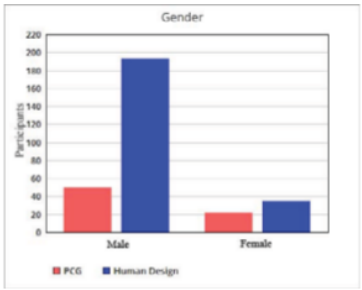

Fig. 3. Compare gender from two group

It can be seen from the results of the comparison graph of the playing experience of the respondents, that the majority of classic or ranked game players (Human design) have more experience than the game mode brawl (PCG) players. However, the data is not enough to prove the immersion of the game against players. Shows the results of a comparison of playing experience from both groups (Figure 4).

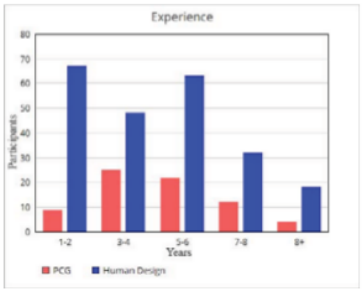

Fig. 4. Compare playing experience form two group

The frequency of players in the PCG game group and the human design group showed a significant comparison, where the majority of respondents chose the human design game mode and the frequency of play chosen was daily. Shows the results of a comparison of the frequency of play of the two groups (Figure 5).

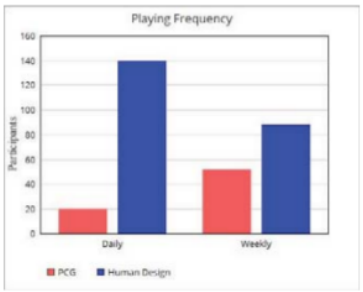

Fig. 5. Compare plating frequency from two group

Both groups will be considered as active players, with the majority in each group playing games every day for more than one hour. However, the *game* mode *brawl player* PCG in the graph shows that players play for more than 3 hours, even though users of the mode *classic* or *ranked* (*Human design*) are very dominating from each session category of that duration. Shows the results of a comparison of the playing duration of the two groups (Figure 6).

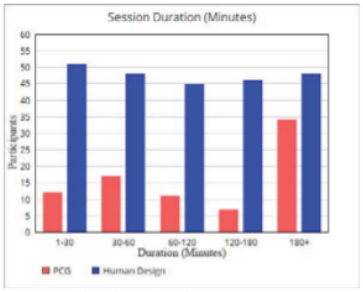

Fig. 6. Compare session duration from two group

From figure 1-6 shows the results of data from two groups based on selected game modes, namely *brawl* (PCG) and *classic* or *ranked* (*Human design*), the majority of data players choose to *game* the *classic* or *ranked* (*Human design*). However, it cannot be ascertained by these data that it can be concluded that human *design is* more *immersive* than PCG. Therefore, data analysis will use several statistical methods, one of which is ANOVA.

A. Two-way ANOVA

The results of the graph have not shown significant statistical results. This can be achieved by using other

statistical methods, namely *analysis of variance* (ANOVA). As proposed by Denisova and Cairns [18]. Table 2 of the summary sample from the ANOVA analysis in the group *human design* uses Excel two-factor ANOVA analysis.

Based on the values of Fhitung, it shows that there is no immersive influence on gender and game frequency classic or ranked mode (human design). Because the value of Fcount is smaller than the value of Fcrit (Fcount = 1.025 <Fcrit = 1204). However, there are significant immersive influences on age, experience, and duration of play. Because the value of Fcount is higher than the value of Fcrit (Fcount = 485,676> 3,016). Table 2 shows the results of ANOVA human design.

TABLE II ANOVA TWO-FACTOR SUMMARY DATA HUMAN DESIGN

Source of Variation	SS	df	MS	F	P-value	F crit
Gender and Playing Frequency	515277,41	227	2269,94	1,025	0,408	1,204
Old, EXP,Session Durstion	2150182,92	2	1075091,46	485,676	1.62	3,016
Error	1004973,08	454	2213,60			
Total	3670433,41	683				

The results of ANOVA summary *two-factor* of the PCG data, show the value of the F-count from gender and the frequency of playing more h is smaller than Fcrit value (F count = 1.06 <Fcrit = 1.39) which means there is no significant effect on immersive a game. As for age, playing experience, the duration of play has an effect on immersive games. Because the value of Fcount is greater than the value of Fcrit (Fcount = 232.6> Fcrit = 3.06). Table 3 shows the final results of the ANOVA *two-factor* PCG.

TABLE III ANOVA TWO-FACTOR SUMMARY DATA FROM PCG

Source of Variation	SS	df	MS	F	P-value	F crit
Gender and Playing Frequency	197000.22	71	2774.65	1.06	0.38	1.39
Old, EXP, Session Durstion	1218179.73	2	609089.87	232.60	1.57	3.06
Error	371843.60	142	2618.62			
Total	1787023,55	215				

So, gender and playing frequency have no effect on immersion games. But age, experience, and duration of play affect immersion games based on the final results of the two-way ANOVA test. The most influential immersion game between human design and PCG is human design, because based on the values α = 0.05, tables 2 and 3 which are the levels of trust or probability of human design have a higher level of confidence compared to PCG (human design = 1.62> PCG = 1.57).

B. One-way ANOVA

Comparing results between previous research methods that use the results of a single-way ANOVA method with the two-way ANOVA method. Because the single way ANOVA method is not conclusive.

Based on the value of Fcount from gender and the frequency indicated there is no significant effect t against immersion games. Because Fcount is smaller than Fcrit (Fcount = 0.327 <Fcount = 1204) Table 4 shows the final results of ANOVA one way based on gender and frequency of play. However, immersion games affect age, experience, and duration of play. Because Fcount is greater than small (Fcount = 481.27> Fcrit = 3.01). Table 5 shows the final results of one way ANOVA based on age, experience, and duration of play.

TABLE IV SUMMARY OF SINGLE-FACTOR ANOVA FROM HUMAN DESIGN GENDER AND FREQUENCY OF DATA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2260.701 .204	227		0.327	1	513177 .77
Within Groups	3,154,74 0.67	456	6918.29			
Total	3,667,91 8, 44	683				

TABLE V SUMMARY ANOVA SINGLE-FACTOR FROM HUMAN DESIGN DATA OLD, EXPERIENCE, AND DURATION SESSION

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2148111. 70	2	10740 55.85	481. 27	5.17	3.01
Within Groups	1519806, 73	681	2231.7 3			
Total	3667918. 44	683				

The results of a single-factor ANOVA summary of PCG data show the value of Fcount from gender and frequency. the play is smaller than the Fcrit value (F count = 0.25 <Fcrit = 1.39) shows the end result of ANOVA one way based on gender and frequency of play, which means there is no significant effect on immersive a game. As for age, playing experience, the duration of play has an effect on immersive games. Because the value of Fcount is greater than the Fcrit value (Fcount = 228.07> Fcrit = 3.04). Table 7 shows the final results of one way ANOVA based on age, experience, and duration of play.

TABLE VI SUMMARY ANOVA GENDER AND FREQUENCY SINGLE-FACTOR FROM PCG DATA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	197000,22	71	2774,65	0,25	1	1,39
Within Groups	1590023,33	144	11041,83			
Total	1787023,55	215				

TABLE VII SUMMARY ANOVA SINGLE-FACTOR FROM HUMAN DESIGN DATA OLD, EXPERIENCE, AND SESSION DURATION

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1218179.73	2	609089,87	228.07	1,13	3.04
Within Groups	568843.82	213	2670.63			
Total	1787023,55	215				

However, gender and frequency of play have no effect on immersion games. But age, experience, and duration of play affect immersion games based on the final results of the two-way ANOVA test. The most influential immersion game between human design and PCG is human design because based on the values $\alpha = 0.05$ table 6 and 7 which is the level of trust or probability of human design has a higher level of confidence compared to PCG (human design = 5.17> PCG = 1.39).

C. Comparison of Two Methods

Test Kolmogorov-Smimmov for testing comparisons between two methods and testing the normality of data analysis from ANOVA two-way and one-way ANOVA.

*1) **Hypothesis testing for normal Human Design ANOVA data two ways**:*

a) Hypothesis: H0 proves error is normally distributed. H1 proved errors with the abnormal distribution.

b) Significance level: A = 5% = 0.05

c) Test statistics: Analysis of gender statistics and frequency of play or P-Value value is 0.40. Analysis of statistics on age, experience, and duration of play or P-Value is 1.62.

d) Decision: Because the P-Value value or probability value is greater than α (0.40> 0.05 and 1.62> 0.05) then H0 is accepted.

e) Conclusion: It can be concluded that errors are normally distributed.

*2) **Hypothesis testing for PCG ANOVA data two way:***

a) Hypothesis: H0 proved error with the normal distribution. H1 is proven to be an abnormally distributed error.

b) Significance level: A = 5% = 0.05

c) Test statistics: Analysis of gender statistics and playing frequency or P-Value value is 0.38. Statistical analysis of age, experience, and duration of play or P-Value value is 1.57.

d) Decision Because the value of P-Value or probability value is greater than α (0.38> 0.05 and 1.57> 0.05) then H0 is accepted.

e) Conclusion: It can be concluded that errors are normally distributed.

*3) **Hypothesis testing for normal one-way Human Design ANOVA data:***

a) Hypothesis: H0 proves error is normally distributed. H1 proved errors with the abnormal distribution.

b) Significance level: A = 5% = 0.05

c) The test statistic: Gender statistical analysis and play frequency or P-Value value are 1. Analysis of age, experience, and duration of play statistics or P-Value value is 5.17.

d) Decision: Because the value of P-Value or probability value is greater than α (1> 0.05 and 5.17> 0.05) then H0 is accepted.

e) Conclusion: It can be concluded that errors are normally distributed.

*4) **Hypothesis test for normal one-way PCG ANOVA data:***

a) Hypothesis: H0 proved error with the normal distribution. H1: Error with abnormal distribution.

b) Significance level: A = 5% = 0.05

c) The test statistic: Gender statistical analysis and play frequency or P-Value value are 1. Analysis of age, experience, and duration of play statistics or P-Value value is 1.13.

d) Decision: Because the P-Value value or probability value is greater than α (1> 0.05 and 1.13> 0.05) then H0 is accepted.

e) Conclusion: It can be concluded that errors are normally distributed.

A comparison of the two methods lies in the value of P-Value. Where the one-way P-Value ANOVA on gender and the frequency of play of both groups (Human design and PCG) are not conclusive, because the results of the analysis are of the same value. So that two way ANOVA is more inclusive and the test results can be concluded well.

IV. CONCLUSIONS

This research shows the results of an immersive comparison between two game versions, namely where the game design level uses the human design and the next game level uses procedurally content generated (PCG). While the statistical results from the one-way ANOVA method do not show conclusive immersion results, while the two-way ANOVA method results in immersion so that it can be concluded to be better than the previous method.

Data availability

The [http://bit.ly/2DsjyHF] data used to support the findings of the study are included in the article.

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